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Moenkhausia hemigrammoides Géry, 1965 (Characidae, Stethaprioninae) in Colombia: new records and comments on morphology

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Abstract
Moenkhausia hemigrammoides Géry, 1965 was described from Suriname and recently found in the Ariari drainage, part of the Orinoco river basin. Here, we formally report the presence of this species in the Ariari and Inírida drainages of the Guaviare River and present morphological data that complement the original description. Our records of *M. hemigrammoides* represent the westernmost distribution for this Guianan species in the Amazonas–Orinoco transition zone.

Keywords
Conservation, freshwater, Guaviare, *Hemigrammus unilineatus*, Neotropical fish, Orinoco, Regional Natural Parks.

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Introduction

Moenkhausia Eigenmann, 1903, which is currently considered an artificial genus (Mirande 2010, 2018; Mariguela et al. 2013), comprises 88 nominal species and is one of the most species-rich genera of Characidae (Lima and Soares 2018). The genus exhibits huge diversity in its morphology, coloration, and diet (Pastana and Dagosta 2014; Dagosta and Marinho 2016). *Moenkhausia* is present throughout South America, mainly in the Orinoco, Amazonas, and Guianas drainages, where most of its species (69) are distributed (van Der Sleen and Albert 2017). In Colombia, 27 cis-Andean species have been reported: seven in the Orinoco (including *Moenkhausia hemigrammoides* Géry, 1965), seven in the Amazon, and 13 shared by both basins (DoNascimiento et al. 2019).

Moenkhausia hemigrammoides is distributed in coastal drainages of Guyana, Suriname, and French Guiana (Reis 2003; Fricke et al. 2019) and has been reported in the Amazon basin of Brazil (Pastana and Dagosta 2014; Dagosta and Marinho 2016). The species strongly resembles *Hemigrammus unilineatus* (Gill, 1858), and no osteological information is available that allows for a better discrimination between these two species. *Moenkhausia hemigrammoides* was recently reported in a species list for the upper Guaviare River drainage (Zamudio et al. 2017), where the fish fauna is poorly known (Lasso et al. 2016). Our work reports *M. hemigrammoides* for Colombia and confirms its inclusion in the list by Zamudio et al. (2017), with the addition of localities in the Ariari drainage and the Inírida rivers, both tributaries of

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the Guaviare drainage in the Upper Orinoco river basin. Additionally, information about number of vertebrae, procurrent caudal-fin rays, supraneurals, gill rakers, and anal-fin hooks are presented to complement the morphological information provided in the original description of the species.

Methods

This study was carried out in Colombian Andean Orinoco river drainages in Meta Department. Two lentic ecosystems directly connected with the Ariari River (Guaviare drainage) were sampled: Parque Natural Regional Laguna de San Vicente (PNRLS; 03°00′53″N, 073°10′36″W; 245 m a.s.l.) in Puerto Rico municipality, and Parque Natural Regional Laguna de Lomalinda (PNRLL; 03°18′00″N, 703°22′04.4″W; 237 m a.s.l.) in Puerto Lleras municipality (Fig. 1). Both PNRLS (4.3 km^2 area) and PNRLL (8.1 km^2 area) are immersed in a high plain. Both areas are surrounded by gallery forest and *Mauritia flexuosa* forests (locally known as morichales) which are interspersed with agricultural and silvopastoral systems. Additionally, we revised the ichthyological collection of the Instituto Alexander von Humboldt (IAvH-P), Museo Javeriano de Historia Natural Lorenzo Uribe Uribe S.J. (MPUJ-PECES), and Instituto de Ciencias Naturales, Museo de Historia Natural, Universidad Nacional de Colombia (ICN-MHN).

During the low-water period, between 17 and 24 February of 2018, we sampled different microhabitats (i.e. sandy or rocky bottoms, lotic, lentic, shaded, with or without submerged vegetation) with a seine (3 m long × 2 m high and 0.5 mm mesh). All fishes collected were fixed in 10% formaldehyde, preserved in 70% ethanol, and deposited in MPUJ-PECES. Each individual was identified to genus (Eigenmann 1903, 1917; Mariguela et al. 2013; Pastana and Dagosta 2014; Dagosta and Marinho 2016; Lima and Soares 2018). For the identification of the species, taxonomic keys (Géry 1977) and the original description (Géry 1965) were used to verify the identification. Specimens were compared with the material deposited at IAvH-P and MPUJ-PECES. Meristic and morphometric data were taken on the left side of all individuals, following Fink and Weitzman (1974), except for head depth, taken from the end of the supraoccipital process, and scales above the lateral line, obtained from the origin of the pelvic-fin (Dagosta 2016; Lima and Soares 2018). All measurements were taken with a digital caliper to the nearest 0.1 mm and are presented in Table 1 as percentages of the standard length (SL), or percentages of head length (HL). To provide osteological information, we cleared and stained three individuals following protocols by Taylor and Van Dyke (1985). The pterygiophore position, gill rakers, anal-fin ray hooks, teeth cusps, small posteriormost dentary teeth, procurrent rays, supraneurals, caudal, precaudal, and total vertebrae, were taken from cleared and stained specimens, indicated by c&s in parentheses.

Collection of specimens was part of the project "Revisión y ajuste al plan de manejo ambiental del Parque Natural Regional Lagunas San Vicente y Loma Linda, en concordancia con el decreto único reglamentario 1076 de 2015", which was developed under agreement no. PS-GCT.2.7.17-385 between the Corporación para el Desarrollo Sostenible del Área de Manejo Especial La Macarena (CORMACARENA) and Consorcio PMA 2017.

Results

***Moenkhausia hemigrammoides* Géry, 1965**

Type locality: Weyne, Matoekasie creek, on the road Albina-Moengo, Cottica river basin [Suriname], Figure 1. Holotype: ZMA 104227 (Géry 1965).

Material examined. Colombia: Meta Department • Puerto Rico: Parque Natural Regional Laguna de San Vicente, small clear water affluent of Laguna San Vicente, tributary of Ariari River, Guaviare river drainage (03° 03′01.3″N, 073°11′22″W), 197 m a.s.l., 19 February 2018, collected by Méndez-López A. and Urbano-Bonilla A. (MPUJ 13549, 19, 21.4–31 mm SL). • Puerto Rico: Parque Natural Regional Laguna de San Vicente. (03° 00′53″N, 073°10′35.7″W), 245 m a.s.l., 19 February 2018, collected by Méndez-López A. and Urbano-Bonilla A. (MPUJ 13571, 6, 2 c&s, 25.8–30.7 mm SL). • Puerto Rico: Parque Natural Regional Laguna de San Vicente, outflow of Laguna San Vicente (02°59′50.4″N, 073°11′ 17.2″W), 229 m a.s.l., 20 February 2018, collected by Méndez-López A. and Urbano-Bonilla A. (MPUJ 13588, 1, 26.2 mm SL). • Puerto Lleras: Parque Natural Regional Laguna Lomalinda, tributary of Ariari River, Guaviare river drainage (03°18′00″N, 073°22′04.4″W), 237 m a.s.l., 23 February 2018, collected by Méndez-López A. and Urbano-Bonilla A. (MPUJ 13641, 7, 25.6–32.8 mm SL). • Puerto Lleras: Parque Natural Regional Laguna Lomalinda. (03°17′55.3″N, 073°21′36.3″W), 274 m a.s.l., 24 February 2018, collected by Méndez-López A. and Urbano-Bonilla A. (MPUJ 13697, 2, 1 c&s 27.15–27.82 mm SL). • San Martin: Laguna Sucia, tributary of Ariari River, Guaviare river drainage (03°24′28.7″N, 073° 27′17.0″W), 259 m a.s.l., 17 October 2011, collected by Urbano-Bonilla A. (MPUJ 10456, 13, 26.2–33.7 mm SL). • Vista Hermosa: Caño Cunimía, tributary of Güejar River, Guaviare river drainage (03°10′43.9″N, 073°39′48.7″W), 262 m a.s.l., 6 February 2012, collected by Urbano-Bonilla A (MPUJ 10457, 1, 23.2 mm SL). • Puerto Lleras: Caño Negro, tributary of Ariari River, Guaviare river drainage (03°14′28.3″N, 073°26′51.0″W), 249 m a.s.l, 6 October 2011, collected by Urbano-Bonilla A. (MPUJ 10682, 1, 20.3 mm SL).

Colombia: Guainía Department • Inírida: Caño Guaribén, tributary of Inírida River (03°37′28″N, 068°11′ 23″ W), 11 September 1976 (IAvH-P 20200, 1, 24.4 mm SL).

Comparative material examined. *Hemigrammus unilineatus*: all from Colombia: Putumayo Department • Puerto Leguizamo: Parque Nacional Natural La Paya,

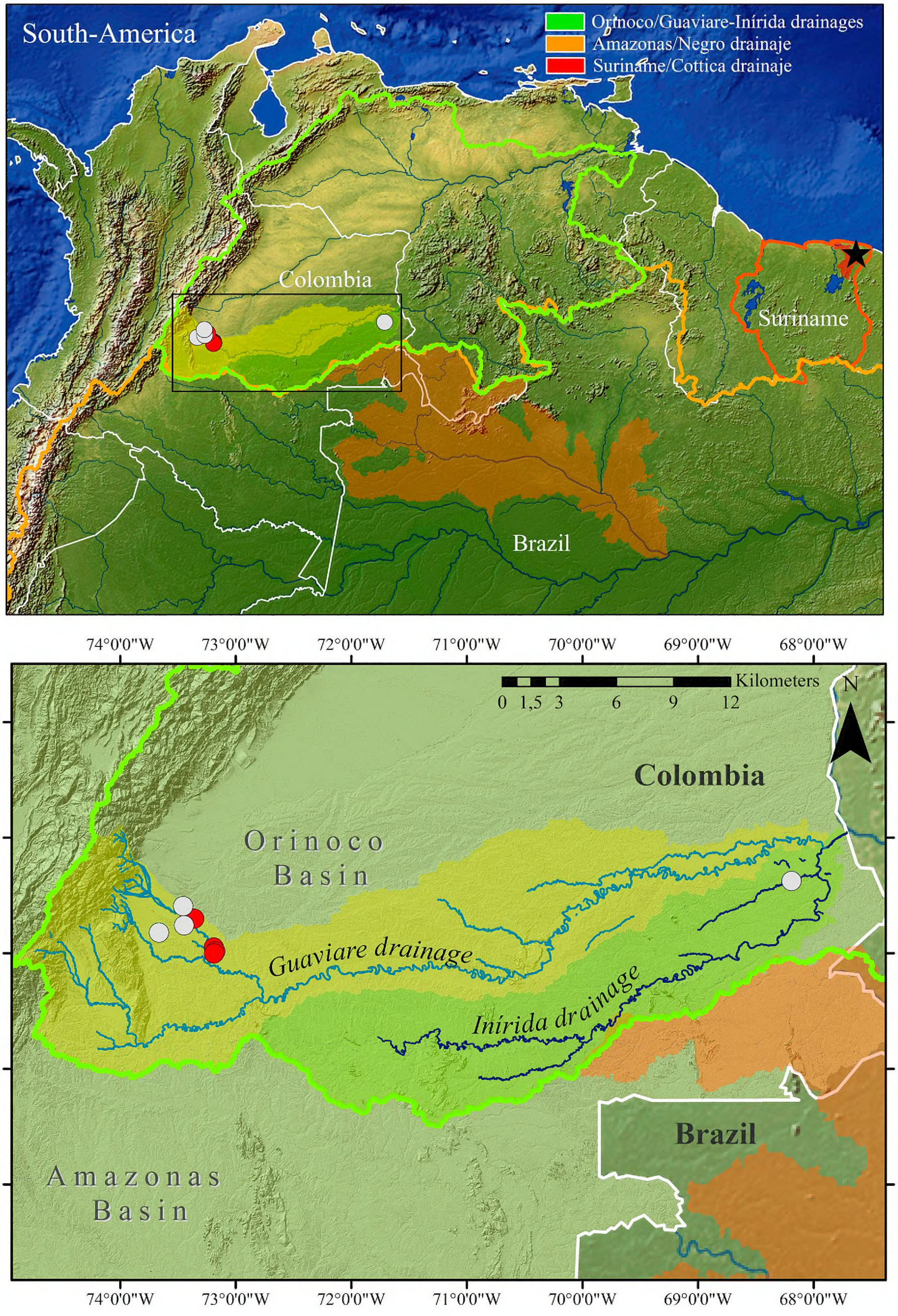

Figure 1. Distribution of *Moenkhausia hemigrammoides* in the Orinoco basin in Colombia (Guaviare and Inírida drainages), Amazon basin in Brazil (Rio Negro drainage), and type locality (Cottica river drainage). Red spots indicating sampling stations in this study, white spots from reviewed material in collections, and star indicating type locality.

Figure 2. *Moenkhausia hemigrammoides*, MPUJ 13549, alive specimen, immediately before preservation.

Garzacocha lagoon, tributary of Caucaya River, Putumayo river drainage, 21 November 2005, collected by Proyecto Ornamentales Amazonas (ICN MHN 14594, 3, 34.3–27.5 mm SL). Caño Yaricaya, tributary of Putumayo River, 17 November 2005, collected by Proyecto Ornamentales Amazonas (ICN MHN 1612, 3, 26.5–24.2 mm SL).

Identification. The new records were confirmed by the diagnostic characters provided in the original description of *Moenkhausia hemigrammoides* (Géry 1965): presence of a black spot between second unbranched and fourth branched dorsal-fin rays, presence of a black oblique band beginning posterior to the anus and ending on the third branched anal-fin ray (Figs 2, 3), 1–3 teeth on the maxillary bone (Fig. 4), 22–25 anal-fin branched rays, and a completely pored lateral line.

Morphological description. Morphometric data presented in Table 1. *Moenkhausia hemigrammoides* have a compressed body, with the greatest depth located anterior to dorsal-fin origin. Dorsal profile of body from head to tail: head convex, slightly straight to concave until end of supraoccipital process, and slightly convex from that point to first dorsal-fin ray; straight and posteroventrally-inclined along dorsal-fin base; straight to slightly convex from last dorsal-fin to origin of adipose-fin and scarcely concave until anteriormost dorsal procurrent caudal-fin ray. Ventral profile of body from head to tail: convex from dentary to anteriormost anal-fin ray, straight and posterodorsally-inclined along anal-fin base and slightly concave from last anal-fin ray to the anteriormost ventral procurrent caudal-fin ray (Figs 2, 3). Mouth terminal, mandibles equal; maxillary bone reaching a slightly anterior portion of orbit. Snout length is shorter than eye diameter. Premaxillary teeth in two rows; external row with four (32; 3 c&s) tricuspid teeth, inner one with five (32; 3 c&s) tetra to hepta-cuspid (3 c&s) teeth (Fig. 4A). Maxilla with one (6; 1 c&s), two (25; 1 c&s), or three (1; 1 c&s) tricuspid teeth (Fig. 4B). Dentary with four (32; 3 c&s) tricuspid to seventh-cuspid teeth, followed by one smaller tricuspid tooth (3 c&s) and 10 (2 c&s) or 11 (1 c&s) small unicuspid teeth (Fig. 4C). Scales cycloid; lateral-line scales (LL) completely pored, with 33 (3),

Table 1. Morphometric data of *Moenkhausia hemigrammoides*. SD (standard deviation).

Measurements	*n*	Range	Mean ± SD
Standard length	35	21.4–32.8	27.9 ± 2.2
Percentages of standard length			
Depth at dorsal-fin origin	35	38.9–46.2	42.3 ± 1.7
Snout to pectoral	35	29.4–32.7	30.8 ± 1
Snout to dorsal-fin origin	35	50.8–54.4	52.5 ± 0.7
Snout to pelvic-fin insertion	35	45–51.3	47.9 ± 1.4
Snout to anal-fin origin	35	62.2–67.6	64.8± 1.4
Dorsal-fin base	35	32.1–39.4	35.6 ± 1.9
Dorsal-fin length	35	31.6–37.6	34 ± 1.4
Pectoral-fin length	35	21.3–26.9	24.1 ± 1.1
Pelvic-fin length	35	17.4–31.3	20.4 ± 2.3
Anal-fin base length	35	32.8–37.4	35.1 ± 1.1
Anal-fin length	35	37.4–44.2	40.1 ± 1.5
Caudal peduncle depth	35	10.7–13.8	11.9 ± 0.7
Caudal peduncle length	35	8.3–11.7	10.3 ± 0.8
Posterior margin of eye to dorsal fin	35	35.8–40.8	37.9 ± 0.9
Head length	35	6.7–9.5	8.2 ± 0.5
Head depth	35	28.2–34.8	30.9 ± 1.2
Percentage of head length			
Horizontal eye diameter	35	40.1–47.2	43 ± 1.8
Snout length	35	19.3–27.5	24.3 ± 1.7
Least interorbital width	35	30.8–34.6	32.8 ± 1
Upper jaw length	35	37.2–44.4	41.5 ± 1.6

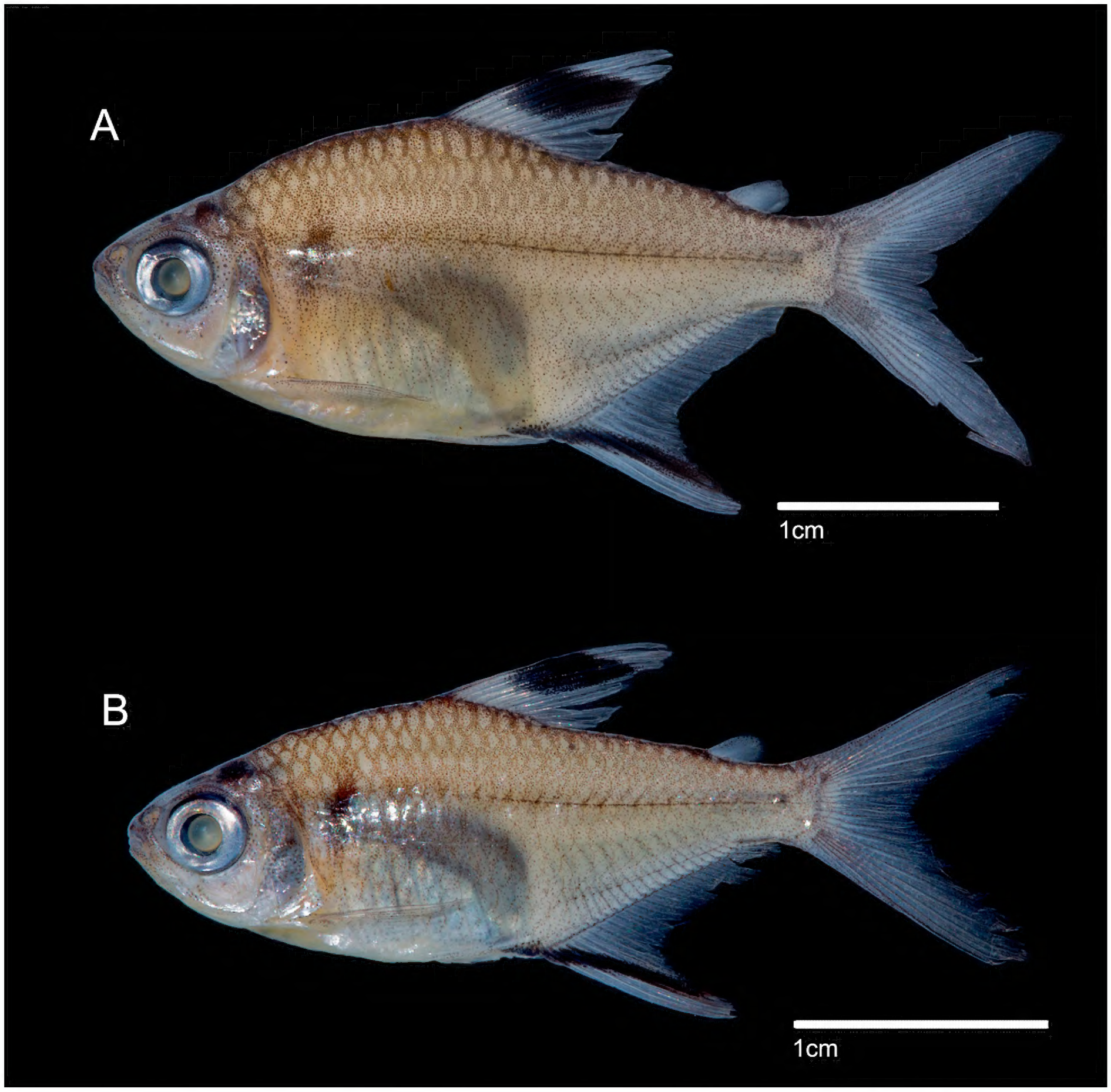

Figure 3. *Moenkhausia hemigrammoides*. **A.** MPUJ 13549, 31 mm SL, female. **B.** MPUJ 13549, 26.4 mm SL, male.

34 (15), 35 (12) or 36 (5) perforated scales. Scale rows between lateral line and dorsal-fin origin five (35); scale rows between lateral line and pelvic-fin origin four (35); circumpeduncular scale rows 12 (35). Caudal-fin forked, lobes equal, with scales covering two-thirds of both lobes; eight (2 c&s) or nine (1 c&s) dorsal caudal fin procurrent rays and seven (3 c&s) ventral procurrent rays. Epurals two. Origin of dorsal-fin located in middle of body. Dorsal-fin rays i, 8 (1), ii, 9 (29; 3 c&s); its first dorsal-fin pterygiophore located behind neural spine of 9th vertebra (3 c&s). Adipose-fin present. Pectoral-fin with i, 10 (9), 11 (21; 2 c&s) or 12 (1 c&s) rays, its tip exceeds pelvic-fin base. Pelvic-fin rays i, 6 (2), 7 (28; 3 c&s), pelvic-fin tip surpassing anal-fin rays. Anteriormost anal-fin pterygiophore inserting posterior to haemal spine of 16th vertebra (3 c&s). Anal-fin rays iiii (3 c&s), 21 (1), 22 (4), 23 (20; 3 c&c), 24 (4) or 26 (1). Paired hooks between last unbranched ray and anteriormost five branched rays in two c&s specimens (Fig. 5). Anal-fin concave along anterior portion, its rays decreasing gradually in length from last unbranched to last branched rays. Supraneurals four (3 c&s). Total vertebrae 32 (2 c&s) or 33 (1 c&s), precaudal vertebrae 14 (3 c&s) and caudal vertebrae 18 (2 c&s) or 19 (1c&s). First gill arch with 1 (2 c&s) or 2 (1 c&s) hypobranchial gill rakers, ceratobranchial with 9 (1 c&s) or 10 (1 c&s) of them, 1 (2 c&s) on cartilage between hypobranchial and ceratobranchial 7 (1 c&s) or 8 (2 c&s) on epibranchial and, 1 (3 c&s) on cartilage between ceratobranchial and epibranchial.

Ecological notes. *Moenkhausia hemigrammoides* was found in lentic water bodies at shallow depths (<1.5 m), turbidity values between 36 and 120 NTU (Nephelometric Turbidity Unit), temperature between 27.7 and 29.8 °C, pH range from 5.4 to 6.0, and dissolved oxygen between 6.1 and 7.7 mg/l. The bottom was composed of sand, silt, and decaying organic matter. Individuals were

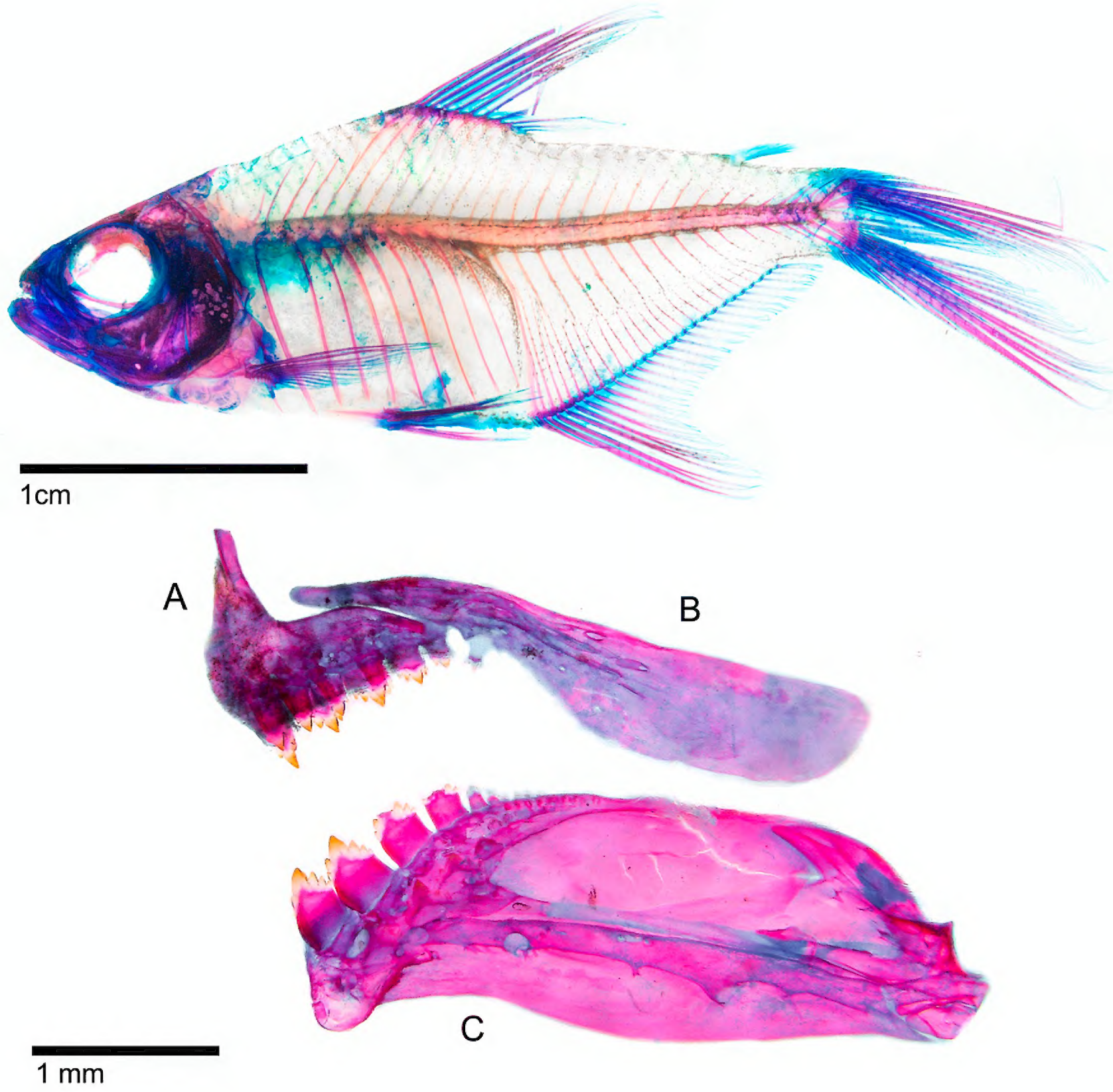

Figure 4. Left side of cleared and stained *Moenkhausia hemigrammoides* (above) and jaws (below), MPUJ 13571, 30.7 mm SL. **A.** Premaxilla. **B.** Maxilla. **C.** Dentary.

frequently associated with roots of aquatic vegetation (*Hymenachne donacifolia*, *Ludwigia hyssopifolia, Paspalum* sp., *Solanum americanum*, and *Scleria latifolia*). They were found sympatric with other characid species (*Astyanax integer*, *Charax niger Ctenobrycon oliverai*, *Gymnocorymbus bondi*, *Hemigrammus analis*, *H. barrigonae*, *H. bellottii*, *H. levis*, *H. micropterus*, *Hyphessobrycon dorsalis*, *Hy. metae*, *Hy. otrynus*, *Jupiaba polylepis* and *Knodus alpha*), and gymnotids (*Eigenmannia limbata*, *E.* sp.).

Discussion

Moenkhausia hemigrammoides was previously recorded in rapid waters, with low turbidity, and on rocky bottoms, usually in schools (Planquette et al. 1996). This study recorded the species during the dry period in two different systems; the greatest abundance was recorded in terra-firme forest stream with clear water, and lowest abundances in lotic ecosystems with turbidity up to 120 NTU (Lagoons San Vicente and Lomalinda lagoons).

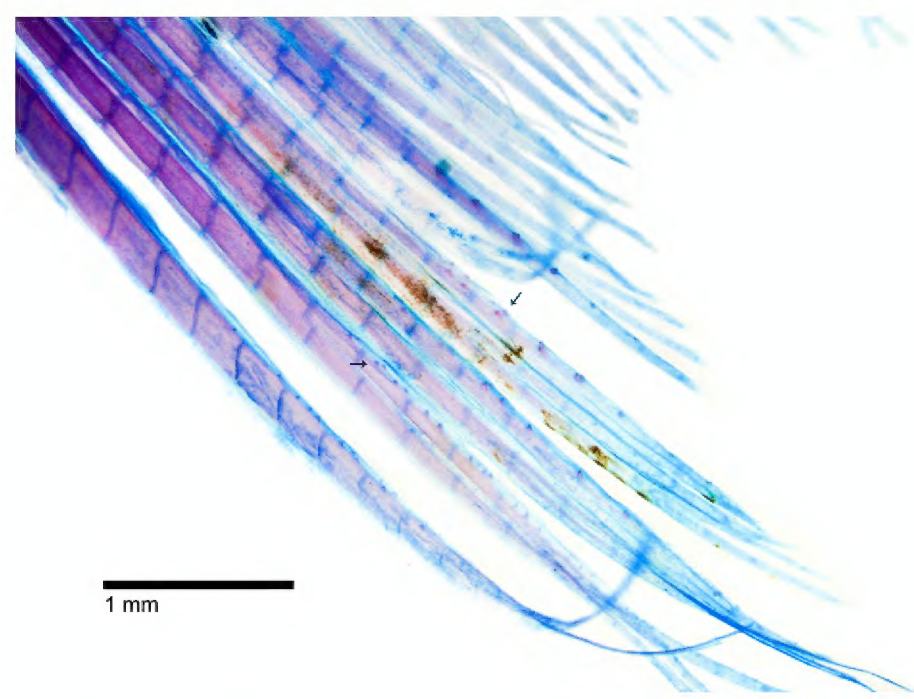

Figure 5. Arrows indicate the paired bony hooks of anal-fin between the last unbranched ray and the fifth anteriormost branched ray of *Moenkhausia hemigrammoides*.

Drought periods influence changes in physical and chemical features of water and possibly on fish communities (Poff and Zimmerman 2010). Therefore, the

presence of the species in different physical and chemical conditions is congruent with its presence in different ecosystems through the Amazon, Guianas, and Orinoco region (Fig. 1).

The Guaviare river drainage is a Ramsar wetland, relevant for conservation in Colombia, which connects the Picachos-Tinigua-Sierra de la Macarena-Chiribiquete (PTMC) mega-corridor (Trujillo et al. 2014; Clerici et al. 2018). Although the Guaviare drainage has been poorly sampled (Lasso et al. 2016), recent studies have found a unique fauna and flora intersection between the Orinoco, Amazonas, Andes, and the Guianas shield (Rial 2018; Vriesendrop et al. 2018; Medina-Rangel et al. 2019). This intersection includes similar faunas among Inírida and Guaviare drainages (Ariari, Duda, and Guayabero rivers). Winemiller et al.'s (2008) results suggest that the Casiquiare River functions as a dispersal corridor between the Negro River and the Upper Orinoco basin. In addition to the type locality (Géry 1965), *M. hemigrammoides* has been reported in the Xingú and Negro drainages, Amazon basin (Lima et al. 2005; Pastana and Dagosta 2014; Dagosta and Marinho 2016). We prove that *M. hemigrammoides* has a wider distribution. The irregular distribution pattern (Fig. 1) might be a result of insufficient sampling (Lasso et al. 2016) or misidentification of the species in collections. For example, IAvH-P 20200 from Inírida drainage was previously identified as *Hemigrammus unilineatus* but is indeed *M. hemigrammoides*.

The similarities between *Moenkhausia hemigrammoides* and *Hemigrammus unilineatus* have been well discussed by Géry (1965, 1977), Planquette et al. (1996), Pastana and Dagosta (2014), Carvalho et al. (2017), and Deprá et al. (2018), and, indeed, a recent phylogenetic hypothesis places them as sister species (Mirande 2018). Following Géry (1965), our data separate these two species by the number of maxillary teeth (1–3 in *M. hemigrammoide*s vs 4–8 in *H. unilineatus*) and the number of transversal scales (5/4 in *M. hemigrammoides* vs 6/5 in *H. unilineatus*), but not in the number of lateral series scales (33–36 in *M. hemigrammoides* vs 33–34 in *H. unilineatus*). Lima et al. (2005) mentioned a complete lateral line and the condition of 5/4 transverse scales for a single specimen of *M. hemigrammoides* from the upper part of the Tiquie River in Brazil. Based on the character matrix for *H. unilineatus* in Mirande (2010), we found differences in the number of supraneurals (4 in *M. hemigrammoides* vs 5 or more in *H. unilineatus*) and in the number of maxillary teeth (1–3 in *M. hemigrammoide*s vs 4 or more in *H. unilineatus*). The examined specimens tentatively identified as *H. unilineatus* from Putumayo River in Colombia (ICN-MHN 14594 and ICN-MHN 14612) have 1–3 maxillary teeth, and scales on 2/3 of the caudal-fin. Consequently, the taxonomic status of these specimens must be reviewed. The populations of *M. hemigrammoides* in the Ariari river drainage presented greater variation in the number of scales in LL (33–36) and bony hooks on the anal fin. The later character is also present in *H. unilineatus* (Fig. 5) and other species of the genus *Moenkhausia* as a secondary sexual character (Géry 1965; Marinho and Langeani 2010). We contribute complementary information on the variation ranges in branched anal fin rays, lateral line scales, cusps in the premaxillary teeth of inner row, and cusps in frontal dentary teeth of *M. hemigrammoides* in comparison to its original description (Table 2).

Occurrences of *M. hemigrammoides* in the Guaviare and Inírida drainages extend the distribution of the species into the Orinoco basin and represent its westernmost records. Contributions to the knowledge of the ichthyofauna in the Guaviare drainage, in this case with a new record, support the relevance of the region for conservation in Colombia, encouraging incremental research of its fishes, to facilitate the implementation of strategies for integrated management of aquatic ecosystems and species.

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Table 2. Range variations in counts of *Moenkahusia hemigrammoides* in comparison to Géry (1965).

Counts	This work	Géry 1965
Branched anal-fin rays	21–26	22–25
Lateral line scales	33–36	31–33
Cusps on premaxillary teeth of inner row	4–7	5
Cusps in frontal dentary teeth	3–7	5

Authors' Contributions

AML and AU-B collected, determined the specimens, and obtained morphological data; AML photographed specimens; AU-B made maps; both authors wrote and reviewed the manuscript.

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